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APPLICATION OF MEMBRANE SEPARATION TECHNOLOGY FOR TERTIARY WASTEWATER TREATMENT

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Abstract: *This paper deals with the applicability of membrane separation processes for the tertiary treatment of wastewater. Set of experiments on membrane separation unit was performed. The aim of experiments was remove contamination so as the water meets the quality requirements for reuse.*

Keywords: membrane technology, nanofiltration, ultrafiltration, wastewater reuse, tertiary wastewater treatment

INTRODUCTION

View of the waste water changing in recent years. Waste water isn´t only unnecessary waste, but thanks to new technologies is becoming a re-usable in many areas. Reuse of waste water is common practice in the world. This problem is not acute in the Czech Republic yet. But the decrescent of underground water supplies and increasing costs of drinking water becomes a question of re-use waste water current.

METHODICS

Treated waste water can be used in several areas. Eg. for urbanized areas, namely watering parks, street cleaning, fire protection, construction work, cleaning buildings, flush toilets. In agriculture, particularly for irrigation of pastures, crops to feed livestock, crops for industrial use. In areas of environmental improvement, especially in the summer months to improve the flow of rivers and replenishment of groundwater. Eg. in Spain is treated wastewater used for feeding the rivers and irrigation of agricultural land (Cazurra 2008).

One other possibility is to provide treated wastewater to drinking water. This method of wastewater reuse is an alternative to building new water sources such as dams. Treated wastewater must meet various quality criteria for further use. For supply water limits must be met by Regulation No. 61/2003 Coll. For drinking water must comply with the limits of the Decree No. 252/2004 Coll.

Like most appropriate technology for tertiary treatment of wastewater appears to membrane separation, because membrane separation technology achieve high efficiency in removing suspended solids, dissolved solids and microbiological contamination. The advantages of this technology include relatively low energy intensity and a great technological strength and stability devices. Membrane systems used for tertiary wastewater treatment are most widespread in Europe, then in North America, Australia or South Africa (Wintgens et al. 2005)

The principle of membrane separation process (Baker 2004) is that the feed solution is divided into concentrate and permeate. The concentrate stream is enriched with retained component and permeate is the purified stream which pass through the membrane. Pressure membrane processes include microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO). The smaller the membrane pore size, the more pressure is needed to ensure sufficient permeate flow through the membrane**.** Dividing range of membranes is characterized by MWCO (molekular weight cut-off), which indicates the molecular weight of molecules that do not pass through the membrane. It is expressed in Dalton (1 D = $1{,}66053.10^{-27}$ kg).

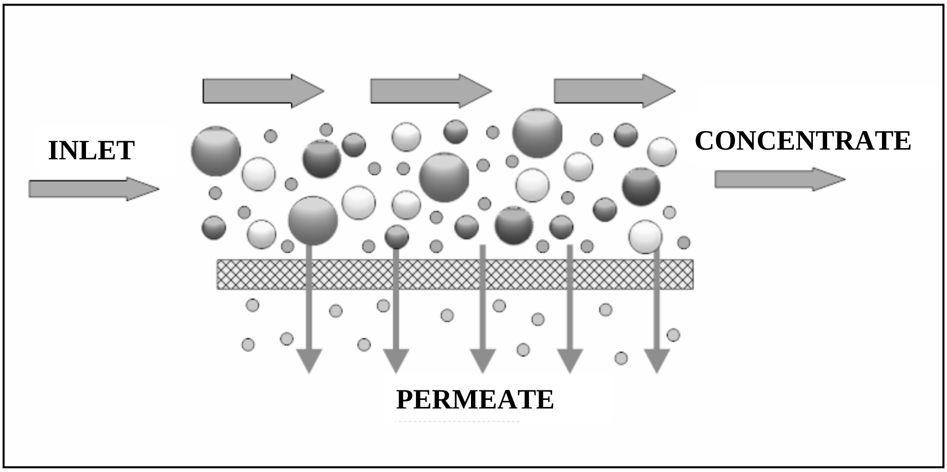

Fig. 1: Principle of membrane separation process

EXPERIMENTS

Membrane separation unit Lab M20 was used for experiments. It isn´t This unit consists of 50lietrs storage tank, piston-membrane pump Wanner G10XK, with engine Siemens 1LA7 and plate and frame membrane module LabStak® M20 from Alfa Laval. For the purposes this study was a module consists of three types of membranes. Names and types of membranes are in tab. 1. Supplier of membranes is Alfa Laval. The area of each membrane is 0.0174 m^2, operate in the range pH 1 – 12 and up to pressure 10 bar. The pressure is adjusted by regulating valve. Flow of treated water is provided by a pump. Setting the drive to 17 – 50 Hz can be selected in the flow range 5 – 15 l/min. This flow was set to 8 L/min for our experiments. Cooling of module and the treated water is provided by two integrated heat exchangers that are cooled by tap water flow. Temperature control is done by setting the desired flow of cooling water.

The experiments were designed to determine the effectiveness of different types of membranes in the removal of chemical and microbiological contamination from water. Membranes which were use in experiments are shown in tab. 1.

Tab. 1: Membranes which were used in experiments

Type of membrane	MWCO [Da]	Matherial	Process
GR 61PP	20 000	polysulfon/polyethersulfon	UF
ETNA 01PP	10 000	composite flouropolymer	UF
NF 45	400	polyamid	NF

Samples from two different municipal wastewater treatment plants were collected for laboratory experiments. Chemical and microbiological analyses of these samples are shown in the tables. All experiments were performed in batch mode. Volume of input sample was always 20 litres. Input solution was circulated through a plate module, permeate is led continuously from the system. Separation was stoped when concentration factor 2.5 was reached. It means that the 60 % of input solution was convert into permeate. The pressure was set to 9 bar during all experiments. The temperature was kept constant at about 20 °C. During the test, the flow rate and input parameters (concentrate) and the instantaneous permeate. The monitored variables were temperature, conductivity, pH and membrane permeation performance.

RESULTS

Here are the analytical results of experiments with water from wastewater treatment plant No. 2.

In tab. 2 are results of chemical analysis of inlet and permeates. In tab. 3 are results of microbiological analysis. We performed a detailed microbiological analysis of water than is required by Reg. No. 61/2003, because the membrane technology is expected to meet the limits set by the Decree 252/2004 Coll., which confirmed the results below.

Tab. 2: Chemical analysis of inlet and permeates

Parameter	Unit	Inlet (sample from WTP 2)	Permeates		
			NF99	ETNA	GR61
NO_3^-	[mg/l]	**6,5**	**3.2**	**5.3**	**5.4**
NO_2^-	[mg/l]	<0.50	<0.50	<0.50	<0.50
$N\text{-}NH_3$	[mg/l]	**2.9**	**1.4**	**2.5**	**2.6**
SO_4^{2-}	[mg/l]	**133.9**	**41.4**	**64.1**	**99.8**
Cl^-	[mg/l]	**120.1**	**47.5**	**114.5**	**114.5**
HCO_3^-	[mg/l]	**260.3**	**47.8**	**210.2**	**224.3**
TOC	[mg/l]	**13.2**	**0.1**	**5.2**	**6.7**
TDS	[mg/l]	**685**	**172**	**586**	**608**
conductivity	[µS/cm]	961	232	797	853
pH		7.7	7.1	7.6	7.6
Na	[mg/l]	**79.1**	**23.1**	**72.9**	**75.5**
Fe	[mg/l]	**0.08**	**<0.05**	**<0.05**	**<0.05**
Pb	[mg/l]	<0.10	<0.10	<0.10	<0.10
Ca	[mg/l]	**88.1**	**9.1**	**67.9**	**76.9**
Mg	[mg/l]	**20.2**	**1.63**	**17.0**	**18.5**
Mn	[mg/l]	0.36	<0.10	0.29	0.30
K	[mg/l]	**18.7**	**7.57**	**16.0**	**16.1**

WTP = wastewater treatment plant

DISCUSSION

The results were as expected. Nanofiltration membrane was the most effective in removing chemical pollutants. But its disadvantage is low permeates flow. Ultafiltration membranes have higher permeate flow than nanofiltration membrane, but they only able to remove organic matter. All tested membranes have hundred-per-cent efficiency in remove pathogens. In permeates were measured higher values of cultivable bacteria. But it should be noted that these values meet the limits for drinking water in the Dec. 252/2004 Coll. Positive readings of cultivable bacteria in permeate does not mean the fact that these bakteria could pass through the membrane. It is a secondary contamination of the permeate output tubes, where it has been idle facilities to increase biofilm. In other experiments, this problem will be eliminated by thorough cleaning of tubes before each experiment.

Tab. 3: Microbiological analysis of inlet and permeates

Parameter	Unit	Sample from WTP2	Permeate GR 61PP	Permeate ETNA 01PP	Permeate NF99
Coliform bacteria	CFU/100 ml	480 000	0	0	0
Escherichia coli	CFU/100 ml	178 200	0	0	0
Intestinal entrerococci	CFU/100 ml	6 600	0	0	0
Clostridium perfringens	CFU/100 ml	4 200	0	0	0
Cultivated bacteria at 22 °C	CFU/1 ml	73 400	19	48	23
Cultivated bacteria at 36 °C	CFU/1 ml	33 600	1	1	0
Microscopic image – abioseston	%	8	3	5	2
Microscopic image – number of organisms	organism/1 ml	200	0	0	0
Microscopic image – number of living organisms	organism/1 ml	200	0	0	0

CONCLUSION

The ultrafiltration and nanofiltration technologies are suitable for tertiary wastewater treatment**.** With the ability of membranes to completely remove pathogens from water is produced hygienically clean water, which can be used in agriculture and urbanized areas**.** Using membrane technology for tertiary wastewater treatment in practice will depend on the purpose for which the treated wastewater is used, and by then it will be the election of the type of membrane.

In laboratory experiments, we will continue. In the near future tests with water from other sewage treatment plants will be conducted. Other types of membranes will be tested. In the future will be performed pilot tests on device LAB M1000 with spirally wound module.

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